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(54) **Continuously variable ratio transmission**

(57) A transmission for a vehicle powered by an internal combustion engine incorporates a variator of which the input sheave 18 is co-axial with the engine shaft 11 and the output sheave 27 lies on a second, parallel, axis together with an epicyclic reduction gear 31 and a differential 36 with output shafts 37, 38. A fluid coupling 12, 14 incorporates a lock-up clutch 26 and a further epicyclic gear 15, 17, 21 with forward clutch 25 and reverse brake 24. A modification has the forward/reverse epicyclic gear between the output sheave and the reduction gear. A further modification, dispensing with the fluid coupling, incorporates an epicyclic gear of which the sun is driven by the output sheave, the annulus drives the input sun of the reducing gear, and the carrier is clutchable either to a chain drive from the engine shaft for variable forward and reverse drive or to the output sheave for variable forward drive.

FIG.1.

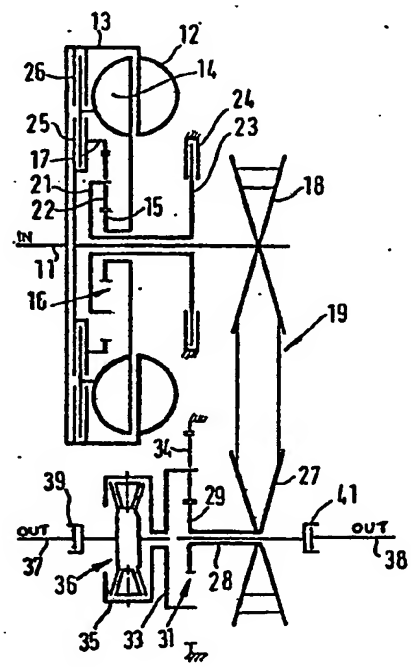

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FIG.1.

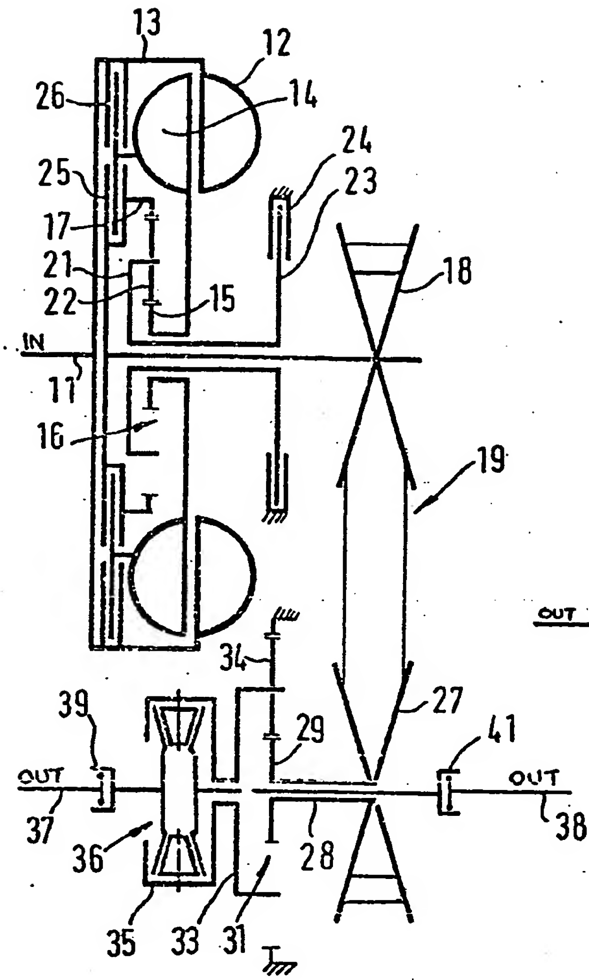
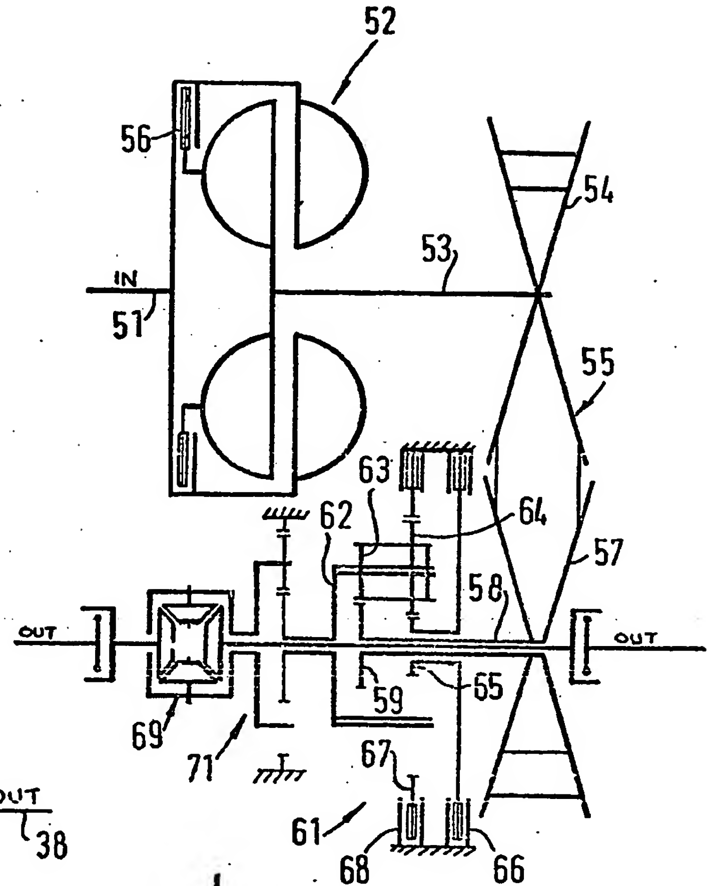


FIG. 2.



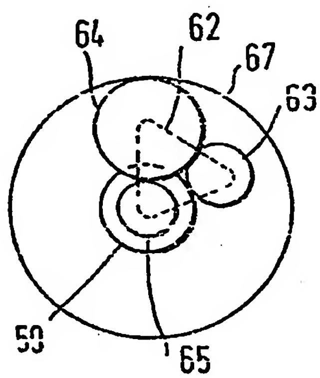


FIG. 3.

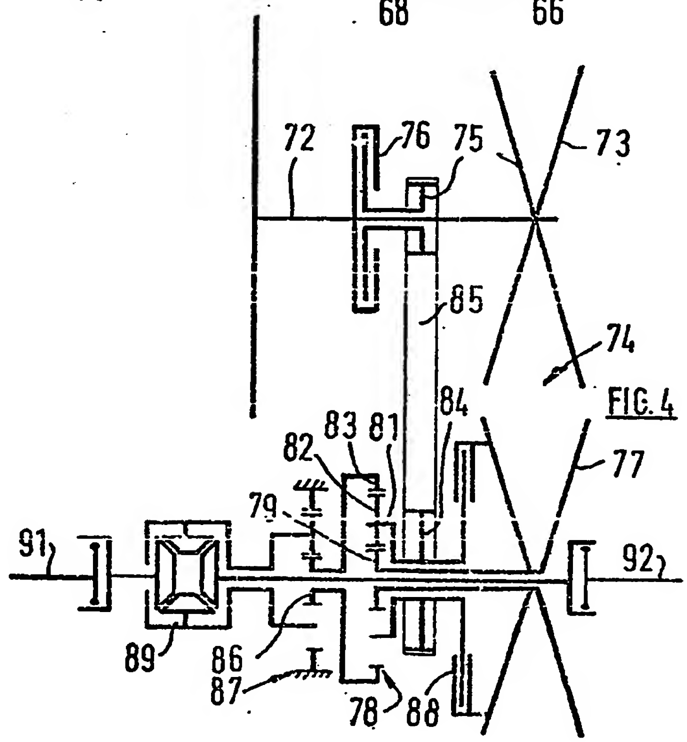


FIG. 4

SPECIFICATION
CVT with output shaft epicyclic

The invention relates to variable ratio transmission mechanisms. The invention is particularly concerned with continuously variable transmission mechanisms for use as the main drive transmission in a vehicle powered by an internal combustion engine.

There is a continuous pressure in the automotive industry and particularly in connection with small front wheel drive cars to provide an increased space within the vehicle without increasing the overall dimensions. This in turn results in a pressure towards compact engine and transmission units and to engine and transmission units which as a whole have a shape which can conveniently be fitted into a space available such as the space between the two front wheels of the vehicle.

The present invention is concerned with the provision of a continuously variable ratio transmission which assists in the provision of a compact and suitably shaped engine-transmission unit. The transmission is of the kind which incorporates a variator. A variator is constituted by a pair of sheaves, each in the form of an adjustable V-pulley, and a flexible friction drive belt or chain interconnecting the two sheaves. Adjustment of the effective diameters of the sheaves by axial adjustment of the relative positions of the two pulley halves of the sheaves, varies the transmission ratio.

According to the present invention there is provided a continuously variable ratio transmission mechanism for use in a vehicle powered by an internal combustion engine and incorporating a variator input sheave on a first axis co-axial with the engine, an output sheave on a second axis parallel to the first axis, a differential unit co-axial with the output sheave and an epicyclic reduction drive from the output sheave to the differential unit, this epicyclic reduction drive also being co-axial with the output sheave.

Preferably there is a coupling member co-axial with the engine for coupling the drive from the engine to the variator.

Preferably the transmission mechanism is also provided with a reverse gearing arrangement.

The reverse gearing arrangement may be an epicyclic reversing gear arranged on the first axis and operatively connected between the coupling member and the input sheave.

Alternatively the reverse gearing arrangement may be an epicyclic reversing gear arranged on the second shaft and connected into the transmission path between the output sheave and the differential unit.

Preferably the coupling is a fluid coupling. However, as an alternative, a different form of coupling such as a friction clutch may be used and the friction clutch may be c ntrolled centrifugally or otherwise.

Preferably the fluid coupling incorporates a lock-up clutch.

As an alternative, the transmission f the invention may include a permanent connection from the engine to the variator input sheave, a further three-element epicyclic gear set lying on the second axis, a reduction drive through a first releasable clutch from the engine to one element of the three-element epicyclic gear set, the other elements thereof being connected to the output sheave and the input to the epicyclic reduction drive respectively, and a second releasable clutch for locking up the further three-element epicyclic gear set, whereby the transmission is operable in two regimes, one with the first releasable clutch engaged to provide reverse, geared neutral or low forward ratios and the second with the second releasable clutch engaged to provide higher forward ratios.

Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic cross section through one form of transmission mechanism conforming to the invention;

Figure 2 is a corresponding cross section through an alternative construction;

Figure 3 is a diagrammatic end elevation of an epicyclic gearing arrangement incorporated in the transmission shown in Figure 2; and

Figure 4 is a cross section corresponding to Figure 1 through a further alternative construction.

The continuously variable ratio transmission mechanism shown in Figure 1 is intended for use as the main drive transmission of a car powered by an internal combustion engine. The engine, not shown, is arranged with its crank shaft axis co-axial with an input shaft 11 to the transmission with the engine immediately to the left (as shown) of the transmission. The input shaft 11 is connected directly to the input section 12 of a conventional fluid coupling by means of a rotary housing 13 which surrounds the output section 14 of the fluid coupling.

The output section 14 is connected to the sun gear 15 of an epicyclic reverse gearing arrangement 16. The annulus 17 of the reverse gearing arrangement forms an output therefrom and is connected for rotation with an input sheave 18 of a variator 19. The reverse gearing arrangement also incorporates a planet carrier 21 which carries planet gears 22 which mesh with both the sun gear 15 and the annulus 17. The planet carrier 21 is connected to the disc 23 of a reversing brake 24 which is capable of holding the carrier against rotation.

A forward clutch 25 is arranged between the output section 14 of the fluid coupling and the input to sheave 18 in order to provide a direct but releasable driving connection from the fluid coupling to the input sheave 18.

Thus in order to provide forward drive from the input shaft 11 to the input sheave 18, the forward clutch 25 is ngaged while the reversing brake 24 is maintained in a released condition. This forward driv is a direct drive with a 1:1 ratio.

Reverse drive is achieved by engaging the

reversing brake 24 while maintaining the forward clutch 25 in a released condition. In this situation, the carrier 21 is held against r tation with the result that the drive from the utput section 14 of the fluid coupling thr ugh the sun gear 15 rotates the planet gears 22 about their own axes and these planet gears in turn rotate the annulus 17 in a reverse direction at a reduced speed. There is then direct drive from the annulus to the input sheave 18 so that the input sheave 18 is rotated in a reverse direction at a reduced speed.

The fluid coupling 12-14 is also provided with a lock-up clutch 26 which is brought into operation after the vehicle has moved away from rest in order to stop slip between the input and output sections of the fluid coupling and thereby improve the efficiency of the transmission as a whole.

An output sheave 27 of the variator 19 is arranged on a second axis displaced from the axis of the variator input, fluid coupling and reverse gearing arrangement. The output sheave 27 is connected by a sleeve 28 to the sun gear 29 of an epicyclic reduction drive 31. The epicyclic reduction drive incorporates a fixed annulus 32. A carrier 33 supports a series of planet gears 34 which mesh with both the annulus 32 and the sun gear 28. Rotation of the sun gear thus drives the carrier 33 at a reduced speed to provide a required. final drive reduction. The carrier 33 is connected to or is integral with the carrier 35 of a conventional differential unit 36. The differential unit 36 drives two unequal length half-shafts 37 and 38 in the usual way. Universal joints 39 and 41 in the output shafts allow for suspension and steering movements.

Figures 2 and 3 show an alternative arrangement. Figure 1 shows an input shaft 51 from an internal combustion engine and this input shaft is connected through a fluid coupling 52 to a further shaft 53 which carries the input sheave 54 of a variator 55. A lock-up clutch 56 is provided to prevent losses due to slip in the fluid coupling under appropriate drive conditions.

The variator output sheave 57 is carried on a sleeve 58 which also carries a first sun gear 59 of a duplex epicyclic reversing gear 61. Reference to Figure 3 as well as to Figure 2 assists in the understanding of the layout of the reversing gear. A carrier 62 is arranged for rotation about the axis of the output sheave 57 and this carrier has two sets of planet gears which are carried on mutually spaced axes and are in mesh with each other. The first sun gear 59 meshes with the first planet gears 63. A second sun gear meshes with the other planet gears 64. This second sun gear is connected to a forward brake 66 which can selectively hold the second sun gear against rotation or allow it to rotate freely. An annulus 67 is also arranged to mesh with the planet gears 64. The annulus 67 is also selectively capable of being held against rotation or allowed to run free by a rev rs brake 68.

For forward driv th forward clutch 66 is engaged to hold the second sun gear 65 against rotation whil th annulus 67 is allowed to rotate freely. In this condition of the duplex epicyclic reversing gear, the carrier 62, which forms the output, is rotated in the same directi n as th first sun gear 59 at a speed ratio depending on the numbers of t th on the various gears. The numbers of teeth may be arranged to give either a small reduction or a small increase in speed.

In order to engage reverse gear, the forward brake 66 is maintained in a released condition and the reverse brake 68 is engaged to hold the annulus 67 stationary. In this condition, the output carrier 62 is rotated in the reverse direction from the rotation of the input sun gear 59, with a reduction ratio.

The carrier 62 is connected through an epicyclic reduction gear 71 to a conventional differential unit 69, these latter components and the output from the differential unit corresponding to the similar components described in relation to the Figure 1 embodiment.

In the embodiment shown in Figure 4, a transmission input shaft 72 is connected directly to an input sheave 73 of a variator 74. The shaft 72 also carries a chain sprocket 75 which can run freely on the shaft 72 but on engagement of a first releasable clutch 76, is caused to rotate with the shaft 72.

The variator also incorporates an output sheave 77 which is arranged on a second axis parallel to but displaced from the first axis, that of input shaft 72. In addition to the epicyclic reduction drive provided in the other embodiments, a further three-element epicyclic gear set 78 is provided on the second axis. This epicyclic gear set incorporates a sun gear 79, a carrier 81 with associated planet gears 82 and an annulus 83. The sun gear 79 is connected for rotation with the output sheave 77. The carrier 81 carries a sprocket 84 which is driven by a chain 85 from the sprocket 75 on the first axis. The annulus 83 is connected to the sun gear 86 of the epicyclic reduction drive 87. A second releasable clutch 88 constitutes a lock up clutch for the epicyclic gear set 78 by locking the output sheave 77 (and thus the sun gear 79) to the carrier 81.

As in the other embodiments, the output from the epicyclic reduction drive 87 is connected, by way of its carrier, to a differential unit 89 which is in turn connected to drive shafts 81 and 82 for the driving wheels of the vehicle.

In operation, the transmission of Figure 4 is controlled to one of two regimes of operation depending on which of the releasable clutches is engaged. In the first regime, which provides reverse ratios, a geared neutral and low forward ratios, depending on the control of the variator, the first clutch 76 is engaged while the second clutch 88 is released. In this first regime, the sun gear 79 of epicyclic gear set 78 is driven by the variator, the carrier is driven through clutch 76 and the chain and sprocket assembly 75, 85, 84 so that the carrier rotates at a speed and in a direction dependant on the relationship b tween the ratios of the two drive paths through the variator and the chain 85 respectively. Certain

variator ratios result in a range of reverse drive ratios for the overall transmission. Other variator ratios result in various forward drive ratios which are relatively low ratios. At a specific intermediate variator ratio, a geared n utral condition arises in that the transmission output speed is zero regardless of engine speed.

In the second regime of operation of the transmission, the clutch 76 is released while the clutch 88 is engaged. Clutch 88 locks up the epicyclic gear set 78. Thus there is a direct drive at variator ratio from the engine to the input sun gear 86 of the reduction gearing 87. The range of variator ratios and of gear and sprocket teeth are selected to give a smooth transition between one regime and the other with a variator ratio which gives equal transmission ratios in the two regimes.

Each of the above embodiments disclose a compact transmission mechanism, partly due to the fact that the whole mechanism is arranged about two axes, namely the engine axis and the axis of the differential unit and output shafts. Such an arrangement can assist in providing space around the engine of a front wheel drive car for other accessories. Another desirable feature in the layout of an engine and transmission combination for a front wheel drive vehicle is that the parts of the transmission associated with the output shaft should be as near to the longitudinal centreline of the vehicle as possible to allow for equal lengths of drive shafts outboard of the universal joints. This requirement is also facilitated by the embodiments of the present invention and particularly the embodiment of Figures 2 and 3 because in that embodiment there is very little of the transmission on the engine shaft to the right of the engine and the remaining parts of the transmission on the output shaft lead back towards the engine and the centre of the vehicle.

CLAIMS

1. A continuously variable ratio transmission mechanism for use in a vehicle powered by an internal combustion engine and incorporating a variator input sheave on a first axis coaxial with the engine, an output sheave on a second axis parallel to the first axis, a differential unit co-axial with the output sheave and an epicyclic reduction drive from the output sheave to the differential unit, this epicycli reduction drive being co-axial with the output sheave.

2. A transmission mechanism as claimed in Claim 1 including a coupling member co-axial with the engine for coupling the drive from the engine to the variator.

3. A transmission mechanism as claimed in Claim 2 and provided with a reverse gearing arrangement.

4. A transmission mechanism as claimed in Claim 3 wherein the reverse gearing arrangement is an epicyclic reversing gear on the first axis, operatively connected between the coupling member and the input sheave.

5. A transmission mechanism as claimed in Claim 3 wherein the reverse gearing arrangement is an epicyclic reversing gear co-axial with the second shaft and operatively connected into the transmission path between the output sheave and the differential unit.

6. A transmission mechanism as claimed in any preceding claim wherein the coupling is a fluid coupling.

7. A transmission mechanism as claimed in Claim 6 wherein the fluid coupling incorporates a lock-up clutch.

8. A transmission mechanism as claimed in Claim 1 including a permanent connection from the engine to the variator input sheave, a further three-element epicyclic gear set lying on the second axis, a reduction drive through a first releasable clutch from the engine to one element of the three-element epicyclic gear set, the other elements thereof being connected to the output sheave and the input to the epicyclic reduction drive respectively, and a second releasable clutch for locking up the further three-element epicyclic gear set, whereby the transmission is operable in two regimes, one with the first releasable clutch engaged to provide reverse, geared neutral or low forward ratios and the second with the second releasable clutch engaged to provide higher forward ratios.

9. A continuously variable ratio transmission mechanism substantially as described with reference to and as illustrated by Figure 1 or Figures 2 and 3 of the accompanying drawings.

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